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# Volcanic stratigraphy and structural geology of the area of the Boston gold deposit, Hope Bay volcanic belt, Nunavut

Ross L. Sherlock and Hamish A. Sandeman

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**Abstract:** The Boston gold deposit, located in the southern portion of the Hope Bay volcanic belt, is the largest known gold deposit in the belt. Rock types in the area of the deposit are dominated by mafic volcanic rocks, with smaller amounts of felsic volcanic and sedimentary rocks. The strata are folded about a large south-plunging $F_2$ synformal anticline cored by mafic pillowed flows that host the Boston deposit. Gold mineralization is associated with a complex anastomosing high-strain zone which is roughly axial-planar to the main anticline and is tentatively interpreted as the latest expression of $D_2$ strain. Overprinting the main ($D_2$) structural elements is a series of cross folds ($F_3$). The folding event that produced the latter created a large embayment of supracrustal rocks into the tonalite-granodiorite on the eastern side of the volcanic belt, and also deformed the gold mineralization and associated alteration at the Boston deposit.

**Résumé :** Le gisement aurifère de Boston est situé dans le sud de la ceinture volcanique de Hope Bay, dont il est le plus important gisement d'or connu. Dans la région du gisement, les affleurements sont surtout constitués de roches volcaniques mafiques; des roches volcaniques felsiques et des roches sédimentaires sont présentes en quantités moindres. Les couches rocheuses forment une synforme anticlinale (faux synclinal) $P_2$ de grandes dimensions, plongeant vers le sud, au coeur de laquelle se trouvent des coulées mafiques en coussins qui encaissent le gisement de Boston. La minéralisation en or est associée à une zone anastomosée complexe, à peu près parallèle au plan axial de la synforme principale, qui a subi de fortes contraintes; cette zone pourrait être l'expression la plus tardive des contraintes associées à la déformation $D_2$. Une série de plis transverses $P_3$ se superposent aux principaux éléments structuraux de la déformation $D_2$. Les contraintes à l'origine de ces plis ont créé une virgation forcée faite de roches supracrustales qui s'enfoncent dans les roches de composition tonalitique à granodioritique situées à l'est de la ceinture volcanique; en outre, elles ont déformé les zones minéralisées du gisement de Boston, ainsi que les zones d'altération qui leur sont associées.

## INTRODUCTION

Gold deposits in the Hope Bay volcanic belt are the targets of some of Nunavut's most advanced exploration projects and represent potential for near-term production. Since the early 1990s, several different deposits have been outlined in the belt, including the Boston and Doris deposits and the Madrid group of deposits (Naartok, Perrin, and Suluk). Each of these deposits is somewhat different in terms of geological setting, alteration characteristics, and local controls on gold distribution. This diversity in gold mineralization, along with abundant outcrop and drill core, low metamorphic grade, and overall low strain, makes the Hope Bay belt an ideal location to characterize mineralizing events in the context of the geological evolution of the host terrane.

This paper reports the results of a semidetailed (1:20 000 scale) mapping program in the vicinity of the Boston deposit.

## REGIONAL GEOLOGY

The Slave Province, which is predominantly an Archean granite-greenstone-metasedimentary terrane, lies between Great Slave Lake and the Coronation Gulf and is bounded to the east by the Thelon-Taltson Orogen (2020–1910 Ma) and to the west by the Wopmay Orogen (1950–1840 Ma; Hoffman, 1988).

About twenty-six granite-greenstone belts are recognized in the Slave Province. Padgham (1985) subdivided these into mafic-volcanic-dominated (Yellowknife-type) and felsic-volcanic-dominated (Hackett River-type) categories. Yellowknife-type belts typically comprise massive to pillowed tholeiitic flows interbedded with calc-alkaline felsic volcanic and volcaniclastic rocks, clastic sedimentary rocks, and, rarely, synvolcanic conglomerate and carbonate units. Hackett River-type belts are dominated by calc-alkaline felsic and intermediate rocks intercalated with turbidites. U-Pb geochronology brackets volcanism in the Slave Province to between about 2715 and 2610 Ma (Mortensen et al., 1988; Isachsen et al., 1991). The volcanic belts typically are isoclinally folded and contain belt-parallel shear zones. Villeneuve et al. (1997) subdivided the intrusive rocks into 2.70 to 2.64 Ga predeformation tonalite and diorite, 2.62 to 2.59 Ga K-feldspar-megacrystic granite, and 2.60 to 2.58 Ga post-deformation two-mica granites.

## HOPE BAY BELT

The Bathurst block (Fig. 1, inset B), a part of the Slave Province that lies northeast of Bathurst Inlet, is isolated from the rest of the Slave Province by the Proterozoic cover of the Kilohigok Basin (Campbell and Cecile, 1976). The Hope Bay volcanic belt lies within the northern portion of the Bathurst Block (Fig. 1). This belt was first mapped at a reconnaissance scale by Fraser (1964), and later in more detail by Gibbins (1987) and Gebert (1993), who considered rocks of the belt to be analogous to those of the Yellowknife Supergroup. The Hope Bay belt is dominated by mafic volcanic rocks, with less common felsic volcanic rocks and their volcaniclastic products, as well as subordinate ultramafic bodies and metasedimentary rocks. U-Pb geochronology of the belt indicates that felsic volcanism spanned a period of at least 53 m.y. (2716–2663 Ma; Hebel, 1999). Overall, the metamorphic facies is lower- to mid-greenschist, except near the contact with the marginal granitoid rocks, where the rocks are hornfelsed to lower-amphibolite facies.

### *Granitoid rocks and their contact relationships with the Hope Bay belt*

To the northeast of the Hope Bay belt (Fig. 1) lie the synvolcanic intrusive rocks described by Thompson (P.H Thompson, unpub. report, 1997). These comprise a suite of mesocratic, grey-weathering, typically medium-grained rocks which are mainly tonalitic in composition but range from granodiorite to quartz diorite. They contain biotite ± titanite ± hornblende ± epidote, and locally, particularly in areas near the supracrustal belt, they host abundant xenoliths and rafts of lower-amphibolite-facies mafic volcanic rocks. The granitoid rocks exhibit a weak to moderate foliation defined by biotite and hornblende, and less commonly have a weak mineral lineation. Overall, foliations dip moderately to the west, but they steepen rapidly near the contact with the supracrustal package. These rocks are locally crosscut by late biotite-monzogranite pegmatite and aplite bodies. Field observations imply that the tonalite intruded the mafic volcanic package, and that in many areas, the contacts were not substantially reworked during later stages of regional strain. A U-Pb zircon age of 2672 +4/-1 Ma (Bevier and Gebert, 1991) for a granodioritic phase at the northeastern margin of the supracrustal belt suggests that this tonalitic suite may represent the intrusive equivalent of felsic volcanic units exposed on the western margin of the Hope Bay belt. Because of their field appearance and petrological character, and in particular because they have the oldest U-Pb age for granitoid rocks in the region, these rocks should be referred to as Group I (synvolcanic) plutons, as suggested by Thompson (P.H. Thompson, unpub. report, 1997).

To the southeast of the southern part of the Hope Bay belt (Fig. 1) and to the west of the smaller Elu volcanic belt lies a suite of leucocratic, white-weathering, typically fine- to medium-grained granodiorite to monzogranite. These rocks contain biotite and magnetite, and commonly host abundant xenoliths and rafts of lower-amphibolite-facies mafic volcanic rocks similar to those of the supracrustal belt. The granitoid rocks exhibit a weak to moderate mineral foliation defined by biotite, and commonly display an anastomosing gneissosity developed through flattening of widespread veins and sheets of monzogranite that intruded a heterogeneous granodioritic body charged with biotitic schlieren and amphibolite inclusions. Overall, foliations generally dip moderately to the west and northwest and rapidly steepen near the contact with the supracrustal rocks. Field observations imply that the gneissic granodiorite intruded the mafic volcanic package and that in many areas, the contacts were not tectonized during later stages of regional strain. A U-Pb zircon age of ca. 2650 Ma (J.S. Gebert, unpub. report, 1999)

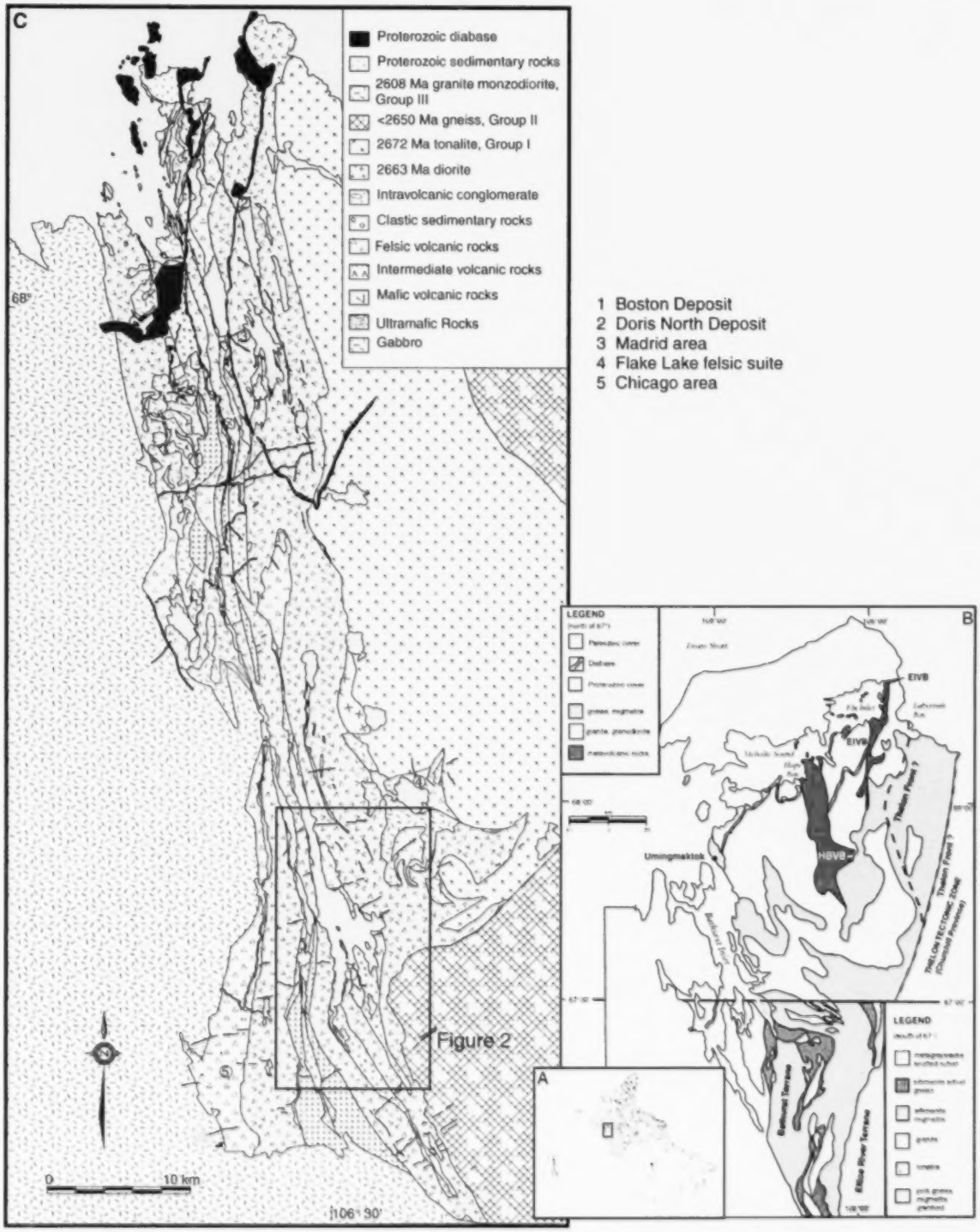



***Figure 1.*** *Regional geology map of the Hope Bay volcanic belt (HBVB)* (modified from *Gebert, 1993*). *Inset (A) shows the location of inset (B), which illustrates the general geology of the Bathurst Block (north of latitude 67°* modified from *Fraser (1964); south of latitude 67°* modified from *Thompson et al. (1986) and Gebert (1993)). The Hope Bay volcanic belt and adjacent Elu Inlet volcanic belt (EIVB) are indicated. Main map (C) shows the generalized geology of the Hope Bay volcanic belt* (modified from *Gebert, 1993*).

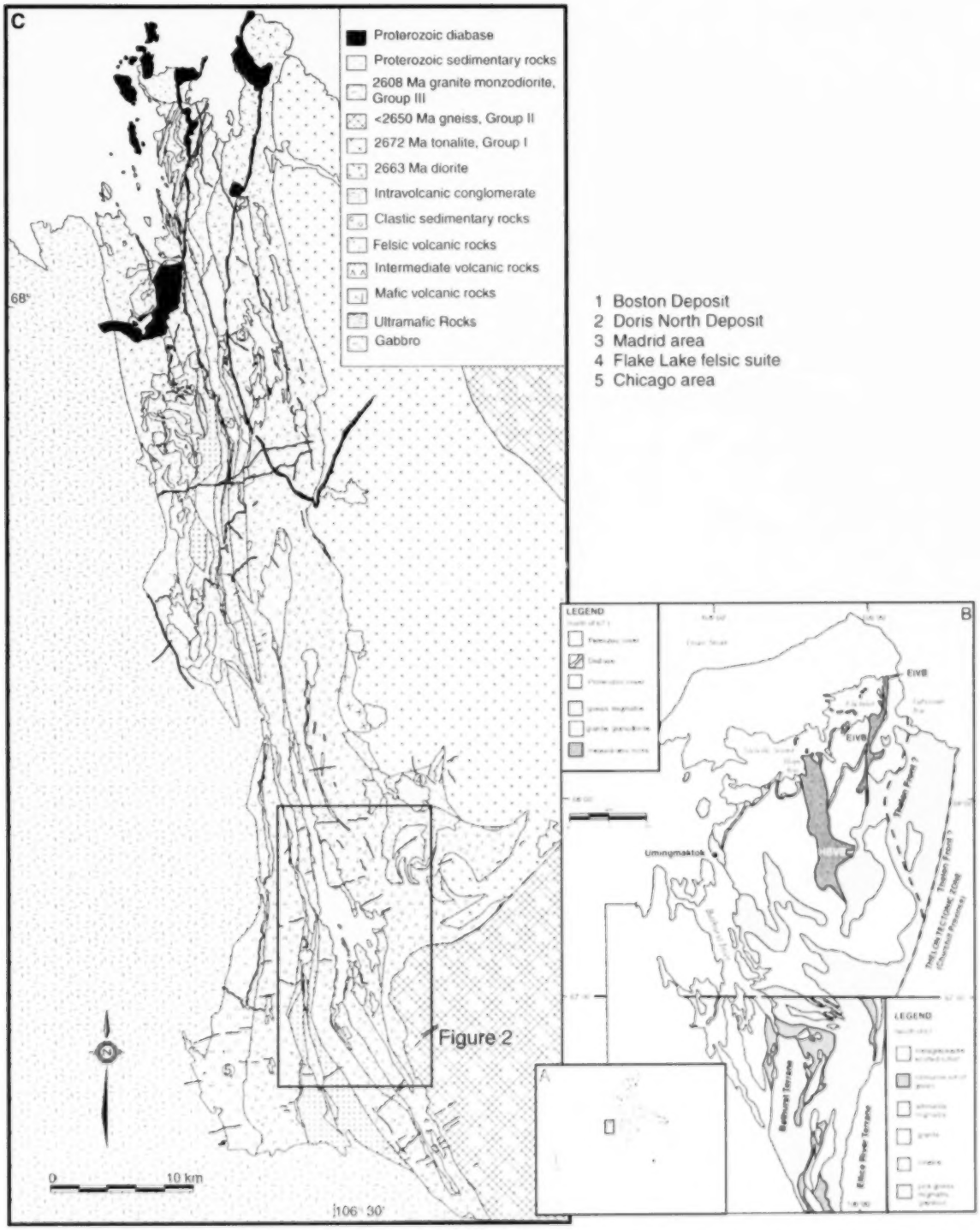



***Figure 1.*** *Regional geology map of the Hope Bay volcanic belt (HBVB)* (modified from *Giebert, 1993*). *Inset (A) shows the location of inset (B), which illustrates the general geology of the Bathurst Block (north of latitude 67°* modified from *Fraser (1964); south of latitude 67°* modified from *Thompson et al. (1986) and Giebert (1993)). The Hope Bay volcanic belt and adjacent Elu Inlet volcanic belt (EIVB) are indicated. Main map (C) shows the generalized geology of the Hope Bay volcanic belt* (modified from *Giebert, 1993*)

for a relatively homogeneous phase at the southeastern margin of the supracrustal belt suggests that this granodioritic suite likely represents a syn- to late-$D_2$ intrusion and has no volcanic equivalents within the supracrustal belt. Although Thompson (P.H. Thompson, unpub. report, 1997) considered these rocks "metagranitoid migmatites", we suggest, on the basis of their field appearance, their petrological character, and in particular their radiometric age, that these are inclusion-charged intrusions which locally underwent multiple phases of deformation, and that they should be referred to as Group II plutons.

The third distinct variety of plutonic rocks exposed in the Hope Bay area outcrops along the entire western margin of the supracrustal belt (Fig. 1). These granitoid rocks vary greatly in composition, from monzodiorite and monzonite to monzogranite, and overall are massive or exhibit very weak foliations. The most common rock type exposed in the northwestern margin of the belt is a pink, leucocratic, medium-grained, microcline-phyric, biotite ± magnetite ± hornblende-bearing granodiorite to monzogranite. This phase was observed to crosscut a slightly older, weakly foliated, fine- to medium-grained, locally epidotized biotite-hornblende quartz monzonite. All of these rocks are crosscut by late, pink-weathering pegmatitic veins and by irregular intrusions of biotite monzogranite. Along the southwestern margin of the belt, west of Spyder Lake, leucocratic, medium- to coarse-grained biotite-hornblende ± magnetite granodiorite is the dominant plutonic phase. This unit is typically massive, but exhibits a weak to moderate foliation in proximity to abundant metre-scale xenoliths of plagioclase-phyric, felsic volcanic rocks. One of these Group III plutonic units (P.H. Thompson, unpub. report, 1997), exposed in the northwestern margin of the supracrustal belt, yielded a U-Pb zircon age of 2608 ± 5 Ma (Bevier and Gebert, 1991), indicating that it likely represents one of the youngest, post-$D_2$ plutonic phases in the region. This suggestion is corroborated by the rare preservation of a weak foliation and abundant inclusions of weakly foliated mafic and felsic volcanic rocks.

## GEOLOGY OF THE AREA OF THE BOSTON DEPOSIT

The Boston deposit (Fig. 2) is the largest gold resource known in the Hope Bay belt, with a measured and indicated resource of 1.387 million tonnes at a grade of 15.4 g/t gold for 687 000 contained ounces of gold, and an additional inferred resource of 2.574 million tonnes at a grade of 10.9 g/t gold for 901 000 contained ounces of gold (Miramar Mining Corp. press release, Jan. 22, 2004). Recent deep drilling has indicated the potential to significantly expand these resources (Miramar Mining Corp. press release, July 23, 2003). The geology of the area includes a bimodal assemblage of mafic and felsic volcanic rocks, along with sedimentary rocks, all of which are complexly folded about a large-scale synformal anticline (Sherlock and Sandeman, 2004).

### *Rock types*

#### Mafic volcanic rocks

Several suites of mafic volcanic rocks are recognized in the area of the Boston deposit; these include the Boston suite and the east and west Spyder suites (Fig. 2). Pillows are similar in shape in the three suites, tending to be rather small with thin selvages and aspect ratios of about 5:1. The pillows are commonly strongly amygdaloidal; amygdales are filled with calcite and epidote, which are often weathered out (Fig. 3A). Due to the flattened nature of the pillows, their geometry does not provide reliable facing indicators. However, pillow shelves are relatively common and are often filled with calcite and epidote, which provide good facing indicators. Interflow sediments are relatively common but volumetrically minor, and consist mainly of argillite with lesser chert.

Variolitic and non-variolitic mafic volcanic rocks form consistent map units. The non-variolitic unit is the most abundant, underlying much of the map area (Fig. 2). In the Boston suite, a distinct variolitic phase (Fig. 3B) can be correlated over several kilometres. In this unit, the varioles are large and mainly developed around pillow selvages, but locally form coalesced varioles that occupy the bulk of a pillow structure. Locally, the varioles are highly elongate, defining a strong stretching lineation. The variolitic unit appears to wrap around the main $F_2$ synformal antiform (discussed below) and may be the main host rock for the Boston deposit. In the deposit area, however, strong hydrothermal alteration obscures most primary textures.

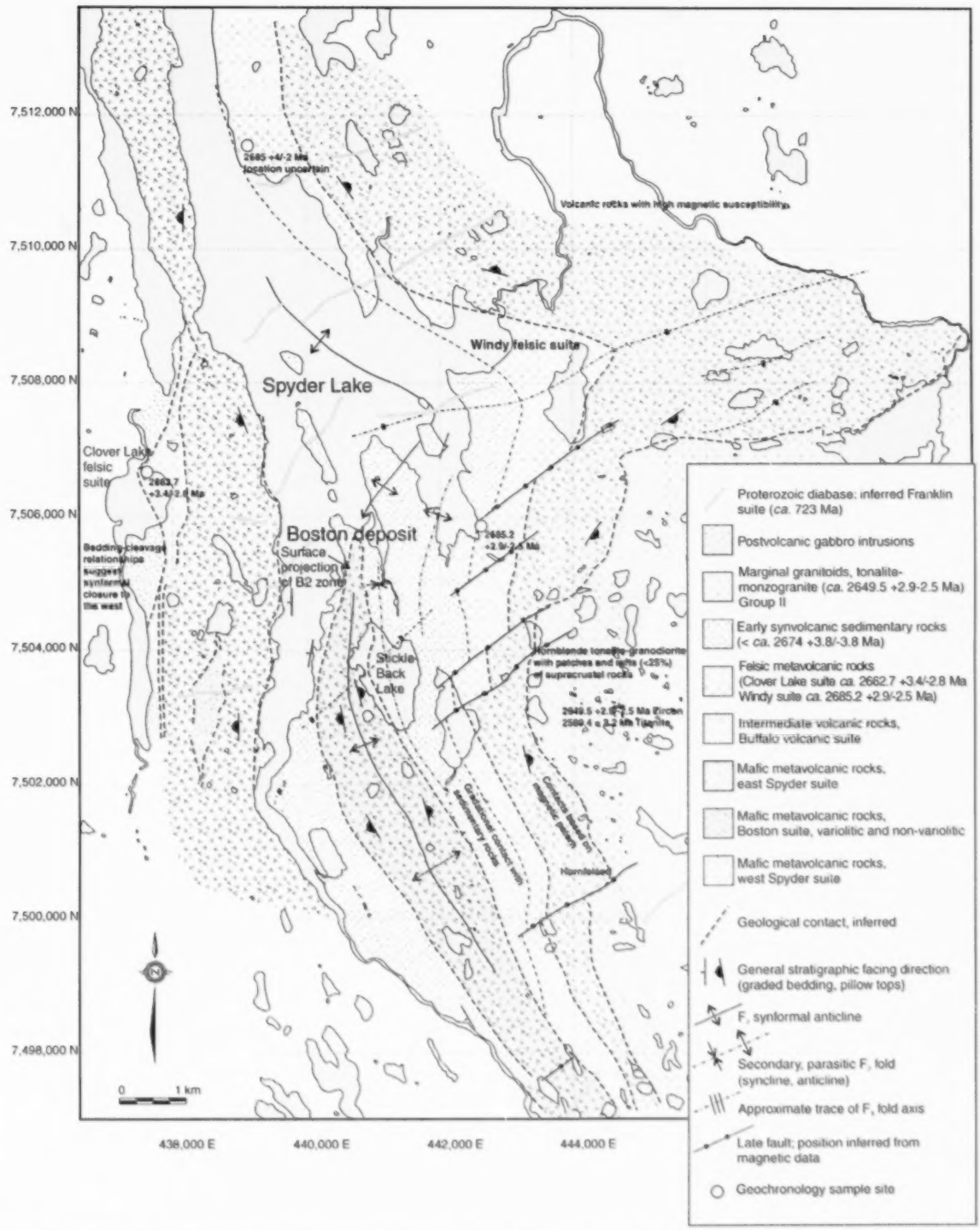
East of the Boston deposit, in the east Spyder suite, the basaltic rocks are strongly hornfelsed up to 300 m from the contact with the tonalite-monzogranite. These rocks consist of a clotted fabric of fine-grained amphibole, which tends to be texturally destructive.

#### Intermediate to felsic volcanic rocks

Two suites of intermediate to felsic volcanic rocks are recognized in the area of the Boston deposit (Fig. 2). To the east of the deposit is an interval of volcanic sandstone to conglomerate (Fig. 3C), interpreted as forming part of the Windy felsic suite (J.S. Gebert, unpub. report, 1999). Clast composition varies from feldspar-phyric to, less commonly, quartz-phyric and aphanitic. Clasts range in size from sand to coarse cobbles over 40 cm across. Bedforms are poorly developed.

Two U-Pb ages have been determined on zircon from the Windy felsic suite in the area of the Boston deposit (Fig. 2): an age of 2685.2 +2.9/-2.5 Ma from the southern portion of the unit (Hebel, 1999) and an age of 2685 +4/-2 Ma from the northern portion of the unit (J.S. Gebert, unpub. report, 1999).

West of the Boston deposit is a small interval of felsic volcanic rocks, informally termed the Clover Lake felsic suite (J.S. Gebert, unpub. report, 1999). These felsic rocks are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1 km
Spyder Lake
Windy felsic suite
Clover Lake felsic suite
Boston deposit
Surface projection of B2 zone
Stickle Back Lake
Volcanic rocks with high magnetic susceptibility
Proterozoic diabase; inferred Franklin suite (ca. 723 Ma)
Postvolcanic gabbro intrusions
Marginal granitoids, tonalite-monzogranite (ca. 2649.5 +2.9-2.5 Ma) Group II
Early synvolcanic sedimentary rocks (< ca. 2674 +3.8/-3.8 Ma)
Felsic metavolcanic rocks (Clover Lake suite ca. 2662.7 +3.4/-2.8 Ma Windy suite ca. 2685.2 +2.9/-2.5 Ma)
Intermediate volcanic rocks, Buffalo volcanic suite
Mafic metavolcanic rocks, east Spyder suite
Mafic metavolcanic rocks, Boston suite, variolitic and non-variolitic
Mafic metavolcanic rocks, west Spyder suite
Geological contact, inferred
General stratigraphic facing direction (graded bedding, pillow tops)
F1 synformal anticline
Secondary, parasitic F1 fold (syncline, anticline)
Approximate trace of F1 fold axis
Late fault; position inferred from magnetic data
Geochronology sample site

***Figure 2.*** *Geology of the area of the Boston gold deposit, simplified from Sherlock and Sandeman (2004). UTM coordinates are zone 13, NAD 83.*

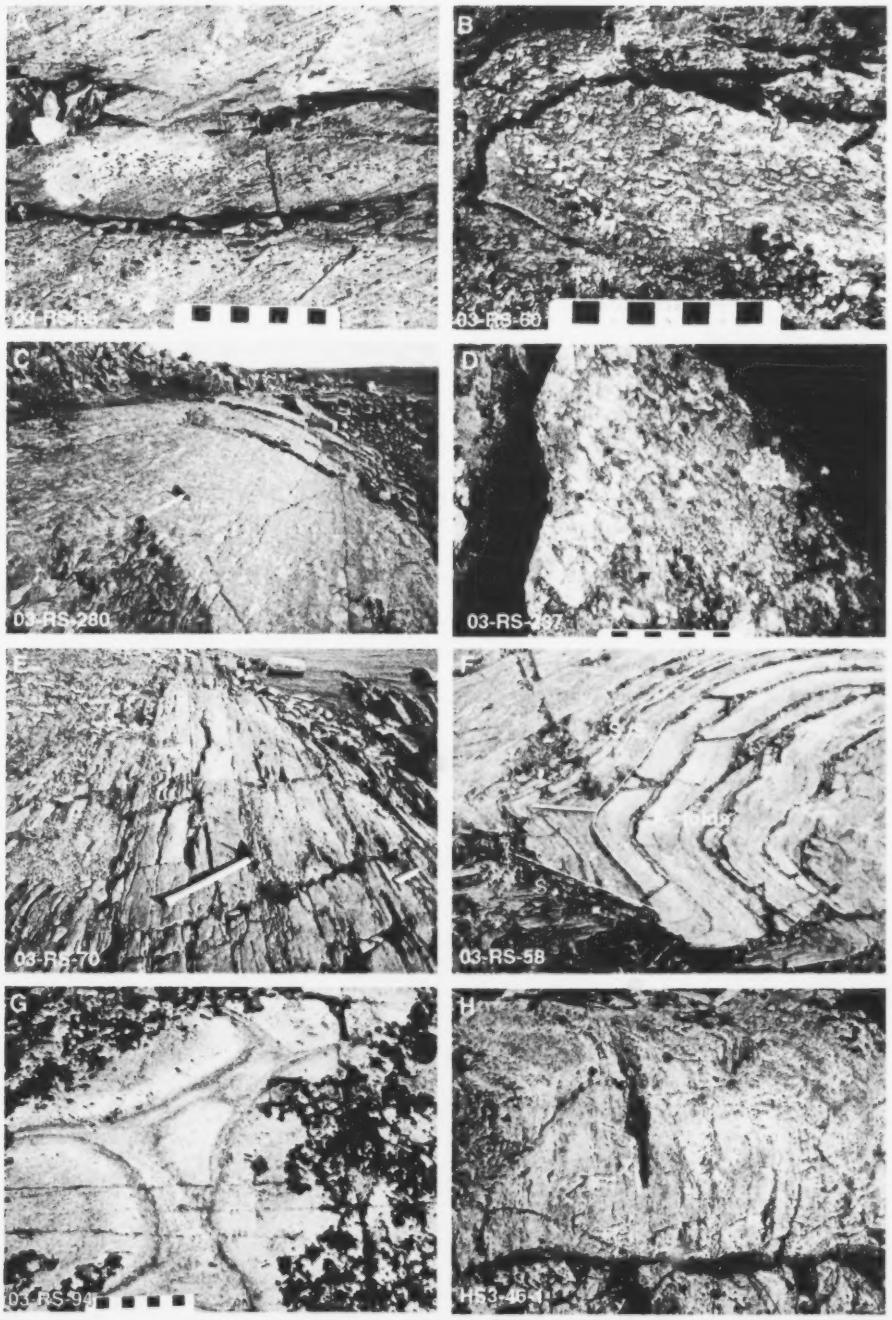


***Figure 3.*** *Rock types in the area of the Boston gold deposit, Hope Bay volcanic belt.* ***A.*** *Pillowed basalt, west side of Spyder Lake, showing strongly amygdaloidal texture (weathered out); UTM 13W, 438698E, 7503382N.* ***B.*** *Variolitic pillowed basalts; UTM 13W, 442064E, 7502202N.* ***C.*** *Dacite volcanic conglomerate, part of the Windy felsic suite; UTM 13W, 440812E, 7510355N.* ***D.*** *Felsic fragments in an argillite matrix, likely a carapace breccia formed by lava-sediment interaction, part of the Clover Lake felsic suite; UTM 13W, 438073E, 7506586N.* ***E.*** *Graded beds with pelitic tops; UTM 13W, 440610E, 7503750N.* ***F.*** *Folded quartzose feldspathic wacke to argillite, showing $S_0/S_1$ fabrics wrapping around a minor $F_2$ fold and crosscut by $S_2$ fabrics; UTM 13W, 442467E, 7502573N.* ***G.*** *Intermediate volcanic rocks, plagioclase-phyric pillowed flows; UTM 13W, 438227E, 7502645N.* ***H.*** *Granodiorite to monzogranite, biotite- and magnetite-bearing, containing abundant xenoliths of mafic metavolcanic rocks and exhibiting an anastomosing gneissosity; UTM 13W, 448892E, 7504025N.*

massive to brecciated and aphyric to quartz-phyric. Near the top of the interval, the felsic volcanic rocks are strongly brecciated in a black argillaceous matrix (Fig. 3D). These textures are interpreted as a carapace breccia formed by quench brecciation as the felsic volcanic lava interacted with unlithified pelitic sediments. One U-Pb age determination on zircon from the Clover Lake felsic suite provided an age of 2662.7 +3.4/-2.8 Ma (Hebel, 1999).

### Sedimentary rocks

These rocks tend to weather recessively and are poorly exposed (Fig. 2). Where exposed on the lakeshores, they range from quartzo-feldspathic wacke to fine-grained argillite (Fig. 3E, F). Most outcrops are well graded, providing excellent facing directions. The sedimentary rocks and felsic epiclastic rocks of the Windy felsic suite are interfingered and form a gradational contact.

### Intermediate volcanic rocks

To the west of the Boston deposit is a thin interval of intermediate volcanic rocks underlying the Clover Lake felsic suite (Fig. 2). These rocks, which range from well shaped pillowed flows to flow breccias, commonly contain plagioclase phenocrysts and are somewhat more leucocratic than the mafic volcanic rocks (Fig. 3G). This unit is informally termed the Buffalo intermediate volcanic suite (J.S. Gebert, unpub. report, 1999).

### Mafic intrusive rocks

A number of gabbroic bodies have been mapped in the area. These are massive, medium- to coarse-grained, homogeneous units that occur within predominantly pillowed flows. They may represent either thicker portions of flows or feeders to the overlying pillowed flows, and are interpreted here to be synvolcanic bodies.

A coarse-grained, hornblende-bearing leucogabbro forms a late intrusive phase throughout the map area (Fig. 2). This intrusive phase, consisting of plagioclase and hornblende with rare quartz, locally crosscuts stratigraphy and is considered to be a postvolcanic mafic intrusion.

### Marginal granitoid rocks

To the east of the Boston deposit (Fig. 2) lies a suite of leucocratic, white-weathering, typically fine- to medium-grained granodiorite to monzogranite (Group II; Fig. 3H). These rocks are biotite- and magnetite-bearing and commonly host abundant xenoliths and rafts of lower-amphibolite-facies mafic metavolcanic rocks similar to those of the supracrustal belt. The granitoid rocks exhibit a weak to moderate mineral foliation defined by biotite and commonly have an anastomosing gneissosity.

### Structural geology

A large-scale south-plunging fold dominates the geology of the area near the Boston deposit (Fig. 2). The geometry of this fold, well constrained by lithological contacts and facing directions, is unusual in that it broadly resembles a synform but has the facing directions of an anticline, making it either a synformal anticline or an overturned anticline. The core of the anticline is occupied by the mafic volcanic rocks that host the Boston deposit, which are overlain by sedimentary rocks. The structure is best defined by facing directions, recognized from graded bedding and bedding-cleavage relationships (Fig. 3E, F; 4A) in the sedimentary rocks and from pillow shelves in the mafic volcanic rocks.

Due to the complex overprinting structural fabrics in the area, only the area of the Boston deposit will be described in detail. As there is a significant flexure in the Boston trend (discussed below), this area has been divided into a northern and a southern domain, within each of which $D_2$ structural elements are relatively consistent.

The earliest fabric recognized is bedding ($S_0$), which is generally well preserved in the sedimentary rocks and also recognized from pillow shelves. A penetrative fabric ($S_1$) is locally recognized parallel to bedding, mainly in fine-grained sedimentary rocks, and is interpreted as a transposition foliation. Due to the overprinting, pervasive, and penetrative $S_2$ fabrics, $S_1$ is only recognized in the hinge of minor $F_2$ folds, where it is preserved parallel to $S_0$ and crosscut by $S_2$ fabrics (Fig. 3F). In the northern Boston domain, poles to $S_0$ form a weak girdle about a pole oriented at 185/62 (Fig. 5A). Similarly, in the southern domain, the poles to $S_0$ form a weak girdle about a pole oriented at 190/67 (Fig. 5B).

Overprinting $S_0/S_1$ is a penetrative fabric which is broadly axial-planar to the $F_2$ fold structure that dominates the area of the Boston deposit. In the northern domain, $S_2$ fabrics tend to strike northeast and dip subvertically (Fig. 5C). In the southern domain, $S_2$ fabrics strike northwest and dip subvertically (Fig. 5D). Also developed in the area of the deposit is a strong south-plunging stretching lineation. In the northern domain, the stretching lineation clusters about an orientation of 200/61 (Fig. 5E), whereas in the southern domain it clusters about 160/70 (Fig. 5F). These orientations are roughly collinear with the fold axes determined from the girdle formed by the poles to $S_0/S_1$ (discussed above).

Small fold structures on the east limb of the main $F_2$ fold (Fig. 2) are recognized by reversals in graded bedding, seen in outcrop and in drill core. These folds are interpreted to be secondary folds to the main $F_2$ synformal antiform, which structurally thickened the package of sedimentary rocks on the east limb of the main $F_2$ fold.

The orientations of structural elements measured from both auriferous high-strain zones and barren unaltered rocks were plotted for the northern and southern domains (Fig. 5C, D, E, F). The clustering of data suggests that there is no apparent difference in orientation of $D_2$ fabrics in auriferous iron-carbonate alteration zones versus unaltered rocks, and therefore that the auriferous alteration zones formed during

$D_2$ strain and are not the manifestation of an earlier mineralizing event subsequently overprinted by $D_2$. The main difference between the two populations is the state of strain, with the iron-carbonate zones being more strained than the unaltered rocks. As discussed below, the alteration zones, recognized in underground exposures and drill core, tend to be localized at lithological contacts.

All early fabrics are broadly folded about northeast-striking, southeast-dipping folds ($F_3$). Fabrics associated with $D_3$ (Fig. 5G) occur in discrete domains and are not uniformly developed across the map area (Fig. 4B). In the area of the Boston deposit, they are concentrated in a domain centred over the north end of Stickle-Back Lake; they are also well developed to the northeast of Spyder Lake in the large embayment of supracrustal rocks. $D_3$ structures deform iron-carbonate alteration zones, and account for the large flexure in the area of the Boston deposit. The latest structures recognized are a set of northeast-trending, late brittle faults with apparent sinistral offset; the location and orientation of these structures are inferred from magnetic data and offsets of lithological contacts along the granitoid-supracrustal contact. These cross folds and late

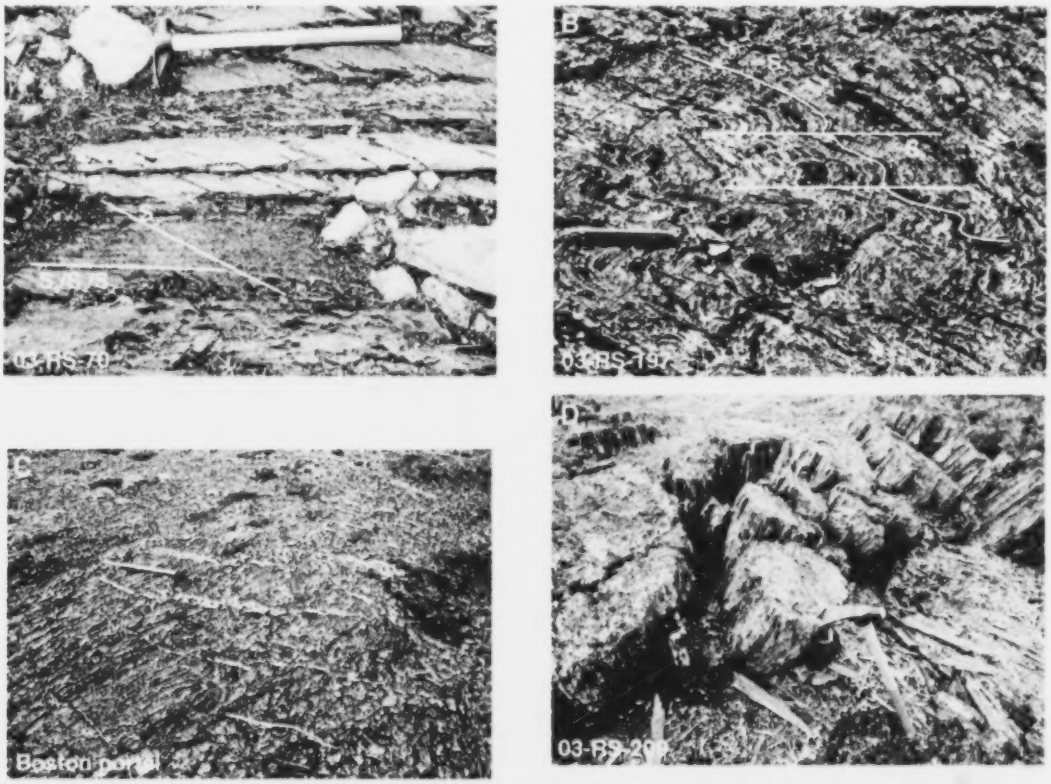


***Figure 4.*** *Structural fabrics and mineralization observed in the area of the Boston deposit.* ***A.*** *Bedding-cleavage relationships in well bedded sedimentary rocks. This geometry is interpreted as an $S_0/S_1/S_2$ composite fabric crosscut by an $S_3$ spaced cleavage; UTM 13W, 440610E, 7503750N.* ***B.*** *Mafic flow breccia with a strong overprinting $S_3$ fabric, commonly developed in the supracrustal embayment to the northeast of the Boston deposit; UTM 13W, 444902E, 7507403N.* ***C.*** *Iron-carbonate alteration with strong $S_2$ fabric and crosscutting extensional ladder veins; UTM 13W, 441235E, 7505323N.* ***D.*** *Strong stretching lineation (L-tectonite) in iron-carbonate alteration zone, south of the Boston deposit; UTM 13W, 441872E, 7501748N.* ***E.*** *Iron-carbonate zones, deformed and boudinaged by $D_3$ fabrics; UTM 13W, 439123E, 7506586N.*

faults are similar to those observed in the northern part of the belt in the area of the Doris and Wolverine deposits (Sherlock et al., 2003; Sherlock and Carpenter, 2003). The age of these structures is uncertain. They clearly deformed the mineralization, but in the northern part of the belt, they did not deform or offset the Franklin diabase intrusions (ca. 723 Ma).

The large embayment of supracrustal rocks to the northeast of the Boston deposit is an unusual feature, as the belt tends to have fairly straight contacts with the marginal granitoid rocks. This embayment is characterized by east-west-oriented $S_2$ fabrics and a strong domain of $D_3$ structural elements. The majority of these rocks are strongly hornfelsed, even into the centre of the embayment, suggesting that they are underlain by and in close proximity to the tonalite-monzogranite intrusive complex. The embayment likely developed as a cross fold ($F_3$) which reoriented the supracrustal-granitoid contact, resulting in a relatively thin skin of hornfelsed supracrustal rocks underlain by tonalite and monzogranite, with a shallow west-dipping contact.

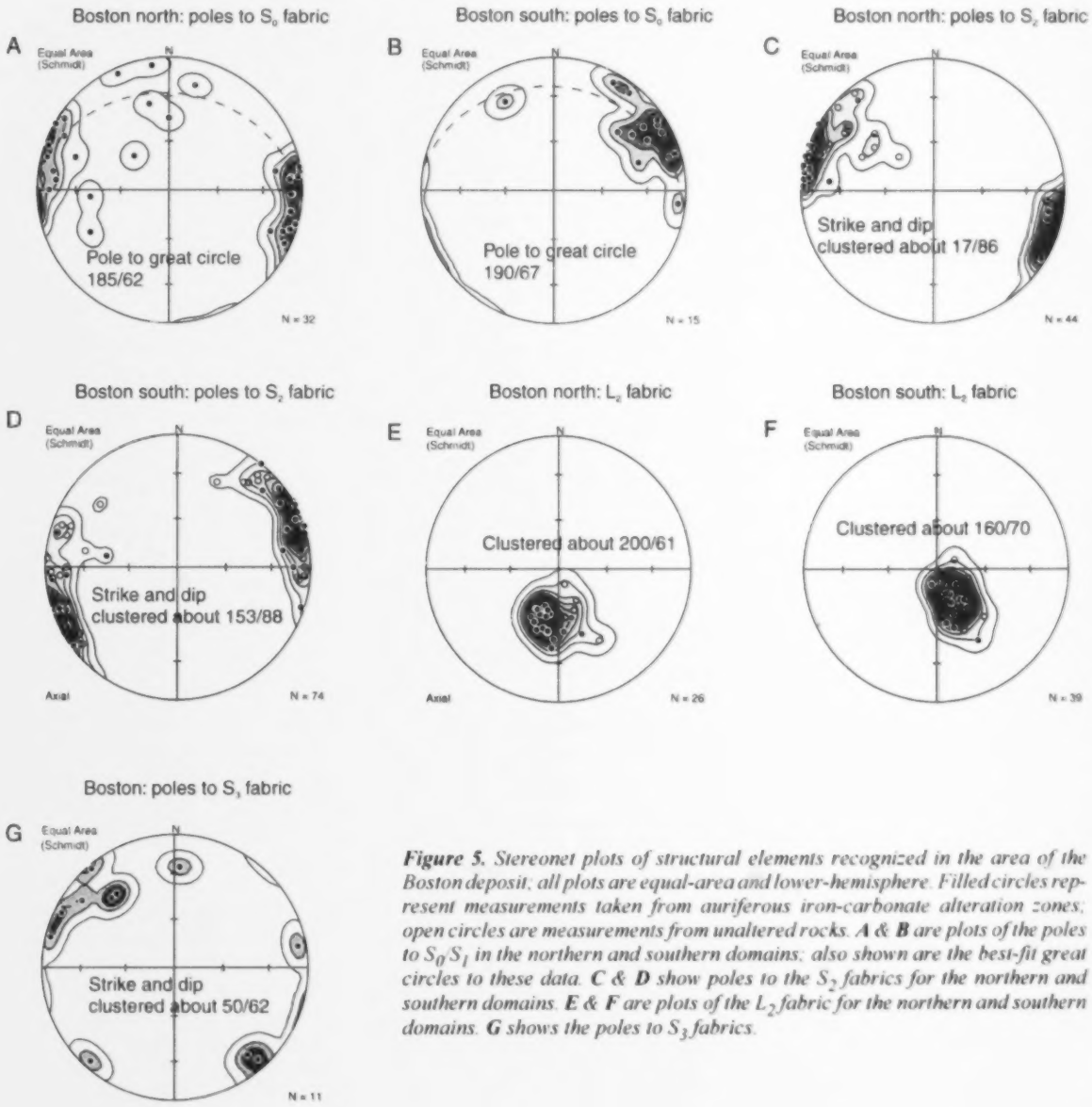


***Figure 5.*** *Stereonet plots of structural elements recognized in the area of the Boston deposit; all plots are equal-area and lower-hemisphere. Filled circles represent measurements taken from auriferous iron-carbonate alteration zones; open circles are measurements from unaltered rocks.* ***A*** *&* ***B*** *are plots of the poles to $S_0/S_1$ in the northern and southern domains; also shown are the best-fit great circles to these data.* ***C*** *&* ***D*** *show poles to the $S_2$ fabrics for the northern and southern domains.* ***E*** *&* ***F*** *are plots of the $L_2$ fabric for the northern and southern domains.* ***G*** *shows the poles to $S_3$ fabrics.*

### *Mineralization*

Gold mineralization at the Boston deposit is associated with a complex high-strain zone that roughly coincides with the main $F_2$ synformal-anticline axis and is localized mainly within the mafic volcanic rocks that occupy the core of the fold. A number of subunits of the mafic volcanic package have previously been recognized, mainly in underground exposures and through drill core. These include mafic volcanic rocks (variolitic and non-variolitic), interflow sedimentary rocks, picritic sills, and andesite dykes (J.S. Gebert, unpub. report, 1999; Stemler, 2000). In this study, however, no clear lithological distinctions could be drawn from surface exposures. In general terms, hydrothermal alteration resulted in a distal assemblage of chlorite and calcite, and a more proximal and intense assemblage of sericite, paragonite, ferroan dolomite/ankerite, quartz, and pyrite. In zones of strong alteration, it is common for all primary textures to have been obliterated. Surface exposures of strongly altered rocks have typically weathered to an ocherous red-brown colour.

In the Boston deposit, gold is contained in a series of subparallel zones, termed B2, B3, etc., consisting of complexly deformed, multistage quartz-carbonate veins with minor tourmaline and sulphides within an iron-carbonate alteration assemblage (Fig. 4C). Gold is contained both in quartz veins as well as in their adjacent alteration selvage. Veins are mainly developed at contacts between mafic volcanic rocks and interflow sedimentary rocks. Sulphides in the mineralized bodies include pyrite, arsenopyrite, and chalcopyrite. Vein paragenesis is complex, as is typical of this style of deposit, and the main stage of mineralization is associated with complexly deformed fault-fill veins and extensional ladder veins (Stemler, 2000).

### *Regional implications*

The timing of mineralization in the area of the Boston deposit is broadly similar to what has been proposed for the areas of the Doris and Madrid deposits (Fig. 1; Carpenter et al., 2003; Sherlock and Carpenter, 2003; Sherlock et al., 2002, 2003). Carpenter et al. (2003) have suggested that in the area of the Doris deposit, dilation and gold introduction occurred during late-$D_2$ time in a progressive deformation environment. In the area of the Madrid deposits and elsewhere in the northern portion of the belt (Sherlock et al., 2002, 2003), textural relationships suggest that gold was introduced late within the progressive $D_2$ deformation history. Current work is underway to try and constrain the absolute age of this regional metallogenic event.

The Windy felsic volcanic suite, which occurs throughout the Hope Bay belt, consists of felsic to intermediate volcanic sandstone to conglomerate that grade into quartz arenite. This unit has a very consistent U-Pb age of 2686 Ma and is recognized intermittently along the entire length of the belt. However, its lithofacies is varied, being dominated mainly by volcanic rocks at the north end of the belt and by sedimentary rocks in the area of the Boston deposit. Similarly, the hanging-wall and footwall rocks of the Windy felsic suite are varied and change along strike. Given the variability of the felsic suite and associated rocks, combined with their consistent radiometric age, it is possible that the Windy felsic suite represents a regional disconformity or erosional surface that separates the belt-wide volcanic strata into an upper and a lower cycle. Perhaps significantly, the larger known gold deposits all occur in the lower volcanic cycle (i.e. in rocks older than 2686 Ma).

The Flake Lake felsic volcanic suite contains the oldest felsic volcanic rocks recognized in the belt, with a U-Pb age of 2716.3 +3.1/-2.6 Ma (Hebel, 1999) and a tholeiitic geochemical affinity, making them a distinctive suite of rocks. These rocks are located approximately 15 km to the northeast of the Boston deposit (Fig. 1, location 4). The Windy felsic suite, on the northeastern side of Spyder Lake, youngs to the northeast towards the older Flake Lake volcanic suite. Similarly, the Clover Lake felsic suite has a U-Pb age of 2662.7 +3.4/-2.8 Ma (Hebel, 1999) and consists of west-facing strata. To the west of this unit are felsic volcanic rocks with U-Pb ages of ca. 2677 Ma (Hebel, 1999) in the Chicago area (Fig. 1, location 5). Fundamental belt-scale structures must exist to the east and west of the Boston area to account for the age relationships and opposing stratigraphic facing. These structures are likely analogous to the $F_2$ folds, or associated thrusts, described for the area of the Boston deposit and the area of the Wolverine and Doris deposits, and as such are prospective gold exploration targets.

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